Assessment of Aerobic Power (Vo_2 Max) in Different Group of Athletic Females in Relation with Body Mass Index and Hemoglobin

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ABSTRACT

Introduction: Vo_2 max is one of the most important indicator of determining cardiopulmonary fitness. The present study was done to find out whether exercise training improves Vo_2 max and if so, among which sports group the highest value was observed. The relationship of height, weight and hemoglobin level on Vo_2 max was also studied.

Aim & objectives:

1. To assess and compare the maximal oxygen uptake (Vo_2 max) in different groups of athletic females.
2. To find out the relationship between Vo_2 max, BMI and Hemoglobin concentration in different groups of female athletes.

Materials & Methods: This study was conducted in the physical education department. Randomly selected Forty trained female athletes, between 18-25 years of age without any medical illness were included in the study group which was subdivided into four groups (Volleyball, Basketball, Khokho & Ball badminton) consisting of 10 in each group. Control group consisted of untrained females of the same age group. Vo_2 max was determined using Bruce protocol in a treadmill test.

Results: Mean value for the Vo_2 max was found to be less in Control (23.065ml/Kg/min) compared to Study group ($p < 0.001$) and among athletes, Vo_2 max was more in the basket ball (36.367ml/Kg/min) players with the maximum height (163.1cm) than other groups. Hemoglobin values were less in study group compared to the control group (p value < 0.001) No significant difference was observed in BMI between the control and study groups.

Conclusion: Endurance training as well as height significantly influences the aerobic power than the BMI & Hemoglobin concentration.

Key words: Athletes, females, Vo_2 max, BMI, Haemoglobin level

INTRODUCTION:

Exercise is a bodily activity that enhances or maintains the physical fitness and overall health and wellness. It is performed for various reasons including strengthening of muscles and heart, improving athletic skills, weight maintenance, as well as for the purpose of enjoyment. Frequent and regular physical exercise

boosts the immune system and prevents the occurrence of heart disease & Type 2 diabetes.

Regular exercise, by increasing flow of blood to various organs of the body, delivers more oxygen, nutrients and thereby improves functioning of the vital organs. The Physiological variables which influence athletic performances are: Vo_2 max, running economy and anaerobic threshold.¹

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One of the most important predictors of endurance performance is $\text{Vo}_2 \text{ max}$.² Aerobic power or $\text{Vo}_2 \text{ max}$ which involves a full functional support from cardio respiratory and metabolic pathways is an appropriate test to study cardio pulmonary fitness. The term “ Vo_2 ” is derived from V-volume of o_2 -oxygen. $\text{Vo}_2 \text{ max}$ is the maximum volume of oxygen in milliliters that the body can consume in one minute per kilogram of body weight during intense, whole-body exercise. Those who are fit have higher $\text{Vo}_2 \text{ max}$ values and can exercise more intensely than those who are not as well conditioned.

As exercise intensity increases so does the oxygen consumption. However, a point is reached where exercise intensity can continue to increase without the associated rise in oxygen consumption. The point at which oxygen consumption plateaus defines the $\text{Vo}_2 \text{ max}$ or an individual's maximal aerobic capacity. Aerobic power, aerobic capacity and maximal oxygen uptake are all terms used interchangeably with $\text{Vo}_2 \text{ max}$.

$\text{Vo}_2 \text{ max}$ averages about 33-36 ml/kg/min in active healthy women in the age group of 20-29 years. It is lower in sedentary individuals (less than 23.6 ml/kg/min).³ Training increases the maximal oxygen consumption ($\text{Vo}_2 \text{ max}$) which is the product of maximal cardiac output and maximal O_2 extraction by the tissues. It is well established that $\text{Vo}_2 \text{ max}$ is higher in female athletes when compared to female non-athletes.⁴ The present study was done to compare the $\text{Vo}_2 \text{ max}$ of different group of athletes.

Maximum Vo_2 varies with age, gender, weight and height.⁵ Studies on the effect of body mass index on

$\text{Vo}_2 \text{ max}$ had shown controversial results. Body Mass Index (BMI) is used for screening the health of the general population as there is a strong correlation between being overweight or obese and having health problems, chronic diseases and premature death. Increased BMI levels have also been associated with decrease in respiratory and cardiovascular system capacity resulting in decreased $\text{Vo}_2 \text{ max}$.⁶ Increased BMI was also found to increase $\text{Vo}_2 \text{ max}$ in physical education students.⁷

$\text{Vo}_2 \text{ max}$ was affected by hemoglobin concentration which determines the oxygen carrying capacity of the blood. In trained individuals it was expected of them to have high hemoglobin concentration as training increases $\text{Vo}_2 \text{ max}$.

Hence the present study was done not only to compare the $\text{Vo}_2 \text{ max}$ of different athletic groups, but also to find out the relationship between BMI, Height and Hemoglobin concentration on $\text{Vo}_2 \text{ max}$ in trained female athletes.

AIM AND OBJECTIVES:

Aim:

To assess the maximal oxygen uptake ($\text{Vo}_2 \text{ max}$), Body Mass Index (BMI) and Haemoglobin level in different groups of athletic females.

Objectives:

1. To compare $\text{Vo}_2 \text{ max}$ of female athletes in different groups like basket ball, volley ball, Kho-kho and ball badminton.
2. To compare Body Mass Index of female athletes in different groups like basket ball, volley ball, Kho-kho and ball badminton.

3. To compare Haemoglobin levels of female athletes in different groups like basket ball, volley ball, Kho-kho and ball badminton.
4. To find out the relation between Vo_2 max, Body mass index & Haemoglobin among athletes and control.

MATERIALS AND METHODS:

The present study is a comparative study conducted in the physical education department, in a private medical college in Tamilnadu over a period of 3 months after obtaining the Institutional Human Ethical Committee clearance. A total number of 50 subjects were selected randomly from Physical education department.

Study group included forty trained, randomly selected female athletes in the age group of 18-25 years who were subdivided into four groups, consisting of 10 members in each group. Athletic females who were representing university sports team such as Volley ball, Basket ball, Khokho and Ball badminton were selected for the study, after obtaining informed written consent from each individual. 10 athletes were selected from volleyball team, 10 from basketball, 10 from khokho and the remaining 10 from ball badminton team.

Control group included 10 non athletic females of the same age group from Rajah Muthiah medical college, who had no particular athletic background. Healthy female athletes who have been involved in sports activities for more than 2 years were included in the study. Female athletes below 18 and above 25 years, those having history of cardiac, respiratory or neuromuscular diseases and with irregular training were excluded from the study.

Data Collection Method And Tools:

Baseline and endline data were collected using a questionnaire. Experiment was conducted in the evening on every day. Vo_2 max, BMI & Haemoglobin levels were measured initially and then after the treadmill test.

Vo_2 max was estimated using a Bruce protocol.⁸ The Bruce Protocol is a maximal exercise test where the athlete works to complete exhaustion as the treadmill speed and incline is increased every three minutes. Because this is a maximal exercise test, this test was performed with reasonable safety accommodations and supervision. The length of time on the treadmill is the test score and can be used to estimate the Vo_2 max value.

Treadmill Test:

Individuals had to run on a treadmill with a starting slope of 0 degree and a speed of 1.7 miles/hr (11 km/hr). The slope was increased at the end of every 3 minute (without taking a pause in the run), till the person is no longer able to continue and the time spent on running was recorded.

Bruce Treadmill Test Stages

Stage 1 = 1.7 mph at 0% Grade
 Stage 2 = 1.7 mph at 5% Grade
 Stage 3 = 1.7 mph at 10% Grade
 Stage 4 = 2.5 mph at 12% Grade
 Stage 5 = 3.4 mph at 14% Grade
 Stage 6 = 4.2 mph at 16% Grade
 Stage 7 = 5.0 mph at 18% Grade
 (mph – miles / hour)

From the total run time an estimate of the athlete's Vo_2 max was calculated as follows:

$$\text{For women } Vo_2 \text{ max} = 4.38 \times (T - 3.9)$$

"T" is the total time of the test expressed in minutes and fractions of a minute

Procedure:

- 1) The assistant sets the treadmill to a speed of 1.7 miles/hour with a slope of 0°.
- 2) The athlete [warms up](#) for 10 minutes.
- 3) The assistant gives the command "GO", starts the stopwatch and the athlete commences the test.
- 4) The assistant, at 3 minutes intervals, adjusts the treadmill slope as per the table below.
- 5) The assistant stops the stopwatch when the athlete is unable to continue.

Body Mass Index (BMI):

BMI is defined as the individual's body weight divided by the square of his or her height. Formula: Weight (kg) / Height (m²). Weight was recorded in kilograms by using a locally made, calibrated, electronic weighing scale, accuracy +/- 0.01 kg. Height was measured in centimeters while standing erect. Reading was taken nearest to 1 cm by using inch tape.

Blood Hemoglobin level was estimated using Sahli's Haemoglobinometer based on colour comparison.

RESULTS:

In this study, 50 females between the age group of 18 to 25 years were selected for assessment of Vo₂ max, in that 40 were trained athletes (each group consists of 10 people) & 10 were controls. Analysis of results were done using Bonferroni multiple comparison test.

Table 1- Comparison of Vo₂ max by grouping

GROUPS	Mean ml/kg/min	Standard Deviation	ANOVA	p Value	Bonferroni multiple comparison test
Volley ball	32.539	4.221	14.290	<0.001	Control Vs All
Basket ball	36.367	5.034			
Khokho	32.999	4.140			
Ball badminton	31.978	4.205			
Control	23.065	2.835			

Table 1 indicates that there is a significant statistical difference (p < 0.001) between the control and study group regarding Vo₂ max. It shows that due to training Vo₂ max is more among athletes compared to the controls.

Table 2- Comparison of Height by grouping

GROUPS	Mean (Cms)	Standard Deviation	ANOVA	p Value	Bonferroni multiple comparison test
Volley ball	158.9	6.640	3.268	0.020	Control vs Basket ball
Basket ball	163.1	6.045			
Khokho	159.1	3.784			
Ball badminton	156.7	3.056			
Control	155.8	4.237			

From the table 2 it is inferred that, Vo₂ max values of the basketball players increased in relation with height of the individuals, when compared to other sports persons and control group.

Table 3- Descriptive statistics of Body Mass Index (Kg/m²) by grouping

Values	Volley ball (n:10)	Basket ball (n:10)	Kho kho (n:10)	Ball badminton (n:10)	Control (n:10)
Minimum	17.100	18.200	17.900	18.500	18.000
Maximum	24.700	27.100	29.000	28.600	29.500
Mean	19.540	20.990	20.890	21.480	22.640
Standard deviation	2.241	2.916	3.444	3.068	3.596

The mean value for the Body mass index in control group is 22.640 and among athletes it is least in volleyball players (19.540). Basketball and khokho players have more or less the same BMI values (20.990) & (20.890) respectively. Table 3 doesn't show any statistical difference in BMI between control group and athletes.

Table 4- Comparison of blood Hemoglobin level by grouping

GROUPS	Mean (G/dl)	Standard Deviation	ANOVA	p Value	Bonferroni multiple comparison test
Volley ball	11.080	1.424	5.387	0.001	Basket ball versus Control & Volleyball
Basket ball	8.720	1.402			
Khokho	9.960	1.551			
Ball badminton	9.860	1.276			
Control	11.340	1.506			

Table 4 shows a significant difference ($p < 0.001$) between control and study group regarding hemoglobin levels.

DISCUSSION:

Maximal exercise test with direct measurement of oxygen uptake is considered the most accurate method of assessing aerobic power. Exercise stress testing is most commonly carried out using a Treadmill. In the present study, Vo_2 max of athletic females engaged in different sports were compared with each other and also with that of controls. Age matched female subjects were chosen for this study as Vo_2 decreases with age.⁹

The result according to Table 1 states that Vo_2 max is more in athletic females (< 0.001) when compared to the control group. This result suggests that endurance training has a beneficial effect on increasing the Vo_2 max values. Earlier studies also have observed similar findings¹⁰. This can be

explained on the basis of many physiological alterations which occur in the body as a result of long term regular exercise.

There is ample of evidence that training can improve the performance of muscles by many adaptations, including increased density of the capillary network in the skeletal muscles increasing the capacity to irrigate muscles with blood.¹¹ The changes that occur include over expression of PGC-1 α resulting in increase in the number of mitochondria and the enzymes involved in oxidative metabolism.¹² The net effect is more complete extraction of O_2 and consequently, for a given work load, less increase in lactate production. In healthy untrained subjects, rapidly increasing lactate levels normally limit exercise tolerance.¹³ Less lactate released by the muscles and excess ventilation, together with an increase in the tolerable minute volume, combine to increase the Vo_2 max. Regular training increases Vo_2 max by increasing cardiac output secondary to increase in stroke volume and an increase in arterio venous oxygen difference.¹⁴

Regarding Vo_2 max among athletes, the values were highest in Basket ball players (Mean : 36.367). The second highest values of Vo_2 max were recorded in Khokho players. (Mean : 32.999). The lowest values of Vo_2 max were recorded in Ball badminton players, and the mean was 31.978.

Basketball is a fast paced, high energy expenditure game when compared to other games that require endurance, speed, strength and hand-eye coordination¹⁵. In a comparative study done on physical fitness of football, volleyball, basketball and hockey players, next to the football players higher level of Vo_2 max was observed in basket ball players.¹⁶

In the present study, the highest Vo_2 max values (p value < 0.020) observed among Basketball players compared to others were found to correlate with their height (Table 2-mean:161.3cms) and this could be due to the increase in the vertical diameter of the lungs, which aids in increased minute volume. Previous studies had observed a similar significant correlation between height and Vo_2 max in young girls as well as in male swimmers and they attributed this to be due to greater lean body mass and larger lung size in tall individuals.^{17, 18}

Table 3 shows that the Body mass index is high in control group (mean=22.640), when compared to the study group but statistically there is no difference between control & study group. Among study group it is comparatively less in volleyball players & more in Ball badminton players. The Basketball and kho kho players have more or less the same Vo_2 max values.

One of the problems associated with Body Mass Index is that there is no way to know if the person is heavily muscled or overweight. Therefore, body fat percentage has been recently recommended as a more accurate measurement of body fatness.¹⁹ The present study result can be explained on the basis that athletes have more muscle mass contributing to the Body mass index, when compared to controls, where it may be contributed by fat.

There were mixed results regarding BMI and Vo_2 max.^{20,21} A negative correlation was observed between BMI and Vo_2 max and that fitness level decreased with increasing body weight. The proposed mechanism could be that with BMI more than 30, the minimum classification for obesity, the functional residual capacity of the lungs is reduced by 25 percent, expiratory reserve volume is reduced

by over 50 percent and decline in several measurements of cardiovascular function are observed. While these functional measurements are not heavily involved in normal breathing, they do drastically limit the lungs' capacity for achieving maximum work and will result in lowered Vo_2 max values.

Few other studies done to assess the relationship between body fat and Vo_2 max have concluded that obese females are as fit as non obese females and they do not have less Vo_2 max.^{22,23} It was found that in a 14 days fitness programme, the absolute Vo_2 max was higher in obese than in normal weight women.

The present study result coincides with the results of the study done on Vo_2 max and body fat percentage in female athletes where Negative correlation was there between Vo_2 max and body fat percentage but was not statistically significant.²⁴

Regarding hemoglobin levels, (Table 4) the control group has the highest value (mean=11.340 g%). Among study group volleyball players has the high hemoglobin values, in khokho & ball badminton players it is more or less same, while Basketball players has the low hemoglobin values. A negative correlation was observed between basketball players and all the other groups on hemoglobin & Vo_2 max.

A reduction of blood hemoglobin concentration characterized by decreased O_2 carrying capacity of blood is expected to decrease Vo_2 . In the present study, the basket ball players exhibiting highest Vo_2 max among all the other groups have low blood hemoglobin. This could be due to expansion of plasma volume in trained individuals caused by

translocation of fluid from the interstitial compartment and increased albumin synthesis by the liver. The plasma volume expansion is greater than the red blood cell expansion and thereby hemoglobin concentration decreases (Sports or pseudo anaemia).^{25,26}

True anaemia in athletes could be due to iron deficiency, exertional hemolysis, and exercise related gastro intestinal bleeding. It was also reported that Vo_2 max is limited by the availability of O_2 and not by the increase in hemoglobin with altitude acclimatization.²⁷ During maximal exercise neither peak cardiac output nor peak leg blood flow are affected by reduced hemoglobin.

From the above reports, it was observed that Vo_2 max values were higher in athletes. BMI has no significant difference between study & control groups. It is also observed that along with endurance training, height of the individual also influences the aerobic power.

CONCLUSION:

In the present study, we have concluded that, compared to control group, aerobic power (Vo_2 max) is increased in athletes. Among athletes, Vo_2 max is increased in basket ball players, when compared with Volleyball, Kho kho & Ball badminton players.

Vo_2 max in the Basket ball players is mainly influenced by endurance training and height of the individual, than the lean body mass. Low Haemoglobin concentration observed in athletic group could be due to sports anaemia. Despite the limiting factors, improving Vo_2 max scores is possible, if an appropriate exercise or training regime is followed.

REFERENCES:

1. Brandon LJ. Physiological factors associated with middle distance running performance. *Sports Med.* 1995; 19(4): 268-77
2. Bassett D.R and Howley E.T. Limiting factors for maximum oxygen uptake and determinants of endurance performance. *Med Sci Sports Exerc.* 2000; 32(1): 70-84
3. Vivian H, Heyward. The physical fitness specialist certification manual, the cooper institute for aerobics research, Dallas TX. Printed in advance fitness assessment and exercise prescription, 3rd edition, biopac systems, Inc., 1998 p-48.
4. Smith S.Bute, Anjali N.Shete, Khan S.T. A Comparative study of Vo_2 Max in Young Female Athletes and Non-Athletes. *IOSR Journal of Sports and Physical Education.* 2014; 1(7): 27-29
5. Jones NL, Makrides L, Hitchcock C, Chypchar T, McCartney N. Normal standards for an incremental progressive cycle ergometer test. *Ann Rev Respir Dis.* May 1985; 131(5): 700-708
6. Ozcelik, Aslan M, Ayar A, Kelestimur H. Effects of Body Mass Index on maximal work production capacity and aerobic fitness during incremental exercise. *Physiological research.* 2004; 53: 165-170.
7. Santu Dhara and Kallol Chatterjee. A Study of Vo_2 max in relation with body mass index (BMI) of physical education students. *Research journal of physical education sciences.* 2015; 3(6): 9-12

8. Bruce RA, Kusumi F and Hosmer D. Maximal O₂ uptake and nomographic assessment of functional aerobic impairment in cardiovascular disease. *American Heart Journal*.1973; 85: 546-562.
9. Majik Malek Mohammad, Shahdak Dadashpour and Parisa Adimi. Predicted values of cardiopulmonary exercise testing in healthy individuals (a pilot study). *Tanaffos*.2012; 11(1): 18-25.
10. Helgerud J, Engen LC, Wisloff U, Hoff J. Aerobic endurance training improves soccer performance. *Medical Science Sports Exercise*.2001; 33: 1925- 1931.
11. Klausen K, Andersen LB, Pelle I. Adaptive changes in work capacity, skeletal muscle capillarization and enzyme levels during training and detraining. *Acta Physiologica Scandinavica*. 1981; 113: 9-16.
12. Wu ZD, Puigserver P, Anderson U, Zhang C, Adelmant G, Mootha V. Mechanisms controlling mitochondrial biogenesis and respiration through the thermogenic coactivator PGC-1. *Cell*. 1999; 98(1):115-124. DOI:10-1016/80092-8674 (00)80611-X
13. Astrand, Per-Olo, Inger Hall Back, Rune Hedman and Bengt Saltin. Blood lactates after prolonged severe exercise. *Journal of Applied Physiology*. 1963; 18(3): 619-622.
14. Ekblom B, Astrands PO, Saltin B, Stenberg J, Wallström B. Effect of training on circulatory response to Exercise. *J Appl.Physiol*.1968; 24(4): 518-528.
15. Vamvakoudis E, Vrabas I, Galazoulas C, Stefanidis P, Metaxas T I, Mandroukas K et al. Effect of Basket ball training on maximal oxygen uptake, muscle strength and joint mobility in young basket ball players. *J Strength Cond Res*.2007; 21(3): 930-936.
16. Mukesh K.M, Ajay K.P, Devarshi C.A. Comparative study of Vo₂ max among the Basket ball, Football, Volleyball and Hockey male players. *International Journal of Applied Research*. 2015; 1(11): 245-247.
17. Bolboli L, Siahkouhian M, Poorrahim A, Narimani M. Is the cardiorespiratory fitness affected by height of young girls? *Pak J Biol Sci*.2008; 11(11): 1510-3.
18. Nikolic Z and Ilic N. Maximal oxygen uptake in trained and untrained 15 year old boys. *Br J Sp Med*. 1992; 26(1): 36-38.
19. Pietrobelli A, Faith MS, Allison DB, Gallagher D, Chiumello G, Heymsfield SB. Body mass index as a measure of adiposity among children and adolescents: a validation study. *J Paediatr*. 1998; 132(2): 204-210.
20. Pribis P, Burtack CA, Mckenzie SO, Thaver J. Trends in body fat, body mass index and physical fitness among male and female college students. *Nutrients*. 2010 Oct; 2(10): 1075-85.
21. Vanderburg PM, Katch FI. Ratio scaling of Vo₂ max penalizes women with large percentage body fat, not lean body mass. *Med Sci Sports Exerc*.1996 Sep; 28(9): 1204-1208.

22. Anjali N Shete, Smitha S Bute, P.R.Deshmukh. A Study of Vo_2 max and body fat percentage in female athletes. Journal of Clinical and Diagnostic Research. 2014; 8(12): BCO1-BCO3.
23. Treuth MS, Figueroa-Colon R, Hunter GR, Weinsier RL, Butte NF, Goran MI. Energy expenditure and physical fitness in overweight vs non-overweight prepubertal girls. Int J obese Relat Metab disord .1998; 22(5): 440-7.
24. Blake A, Miller W C, Brown D A. Adiposity does not hinder the fitness response to exercise training in obese women. J of sports med phys fitness. 2000; 40:170-7.
25. Walter F Boron, Emile L Boulpaep. Medical physiology. Section X. Exercise physiology and Sports Science. 2nd edition, Elsevier Saunders, 2012 p 1265.
26. Warkar Anil B, Shekokar Pravin P, Asia Anju A. Sports anaemia in Endurance Athletes: A Physiological phenomenon. International Journal of Applied Biology and Pharmaceutical Technology. 2015; 6(3): 1-8.
27. Calbet JA, Radegran G, Boushel R, Sondergaard H, Saltin B, Wagner PD. Effect of blood hemoglobin concentration on Vo_2 max and cardiovascular function in lowlanders acclimatized to 5260 m. J Physiol. 2002; 545: 715-28.

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